AN OLD HIGH-SPEED LOCOMOTIVE.

BY HERBERT T. WALKER.

The locomotive engine is now more than one hundred years old, and has attained a degree of perfection that is little short of marvelous, even to those who have given the subject but superficial study. Like other highly developed pieces of mechanism, its various parts and their co-relation and proportions have been slowly evolved by years of intense thought and study on the part of men who, having but few precedents for their guidance, were often confronted by problems which could only be solved by a wearisome process of trial and error, and under adverse conditions unknown to the engineer of to-day.

It is true that the problems of modern locomotive design still demand much study; but in the way of proportions of parts, such rules, as for instance the ratio of grate area to heating surface, the diameter of driving wheels to length of piston stroke, the adhesive weight to tractive effort, and so on, have been, by this time, fairly well established. It is thus comparatively easy for the modern engineer to design a locomotive, since he has all the rules, data, and literature ready to hand, and skilled mechanics with the finest tools waiting to incorporate his ideas; so that the genius of such men as Trevithick, Hackworth, and Stephenson, who not only originated their designs, but often built the engines themselves, becomes at once apparent. In short, the early locomotive engineers were living examples of the aphorism that "failures are the pillars of success."

With these preliminary remarks, and before introducing a peculiar and interesting locomotive to the reader, it is necessary to call attention to the fact that the locomotive engine is an offshoot of the stationary engine, and its early examples (except those of Trevithick) show the influence of the fixed engine developed by James Watt, which accounts for most of the oldest locomotives having upright cylinders, vibrating beams, and low piston speed. Even the rails were laid on stone sleepers, after the manner of stationary engine foundations. When the locomotive had assumed practically the same arrangement of parts and general appearance which it has to-day, the influence of stationary engine practice still clung to it, and one of the principles governing locomotive design was that the piston speed should be kept as nearly as possible to the usual rate of Watt's pumping engines, namely, 220 feet per minute. With this absurdly low rate as a standard, the only way to build a high-speed locomotive was to enlarge the diameter of the driving wheels, and this fallacy led to the production of some engines with wheels of no less than 10 feet diameter (even 15 feet were proposed) which, after a few trials, were soon laid aside and broken up. As the size of driving wheels could not be increased without raising the boiler, the early locomotive men found themselves confronted by another dilemma, namely, the "low-boiler" theory, by which it was held that the boiler of a locomotive should be kept as near to the rails as possible to insure steadiness and safety at high speeds. This, like other imaginary troubles, proved to be the most serious obstacle in the path of true and practical progress, and a book could be written describing the fearful and wonderful designs introduced by men both in and out of the profession to meet a difficulty which had absolutely no foundation in fact.

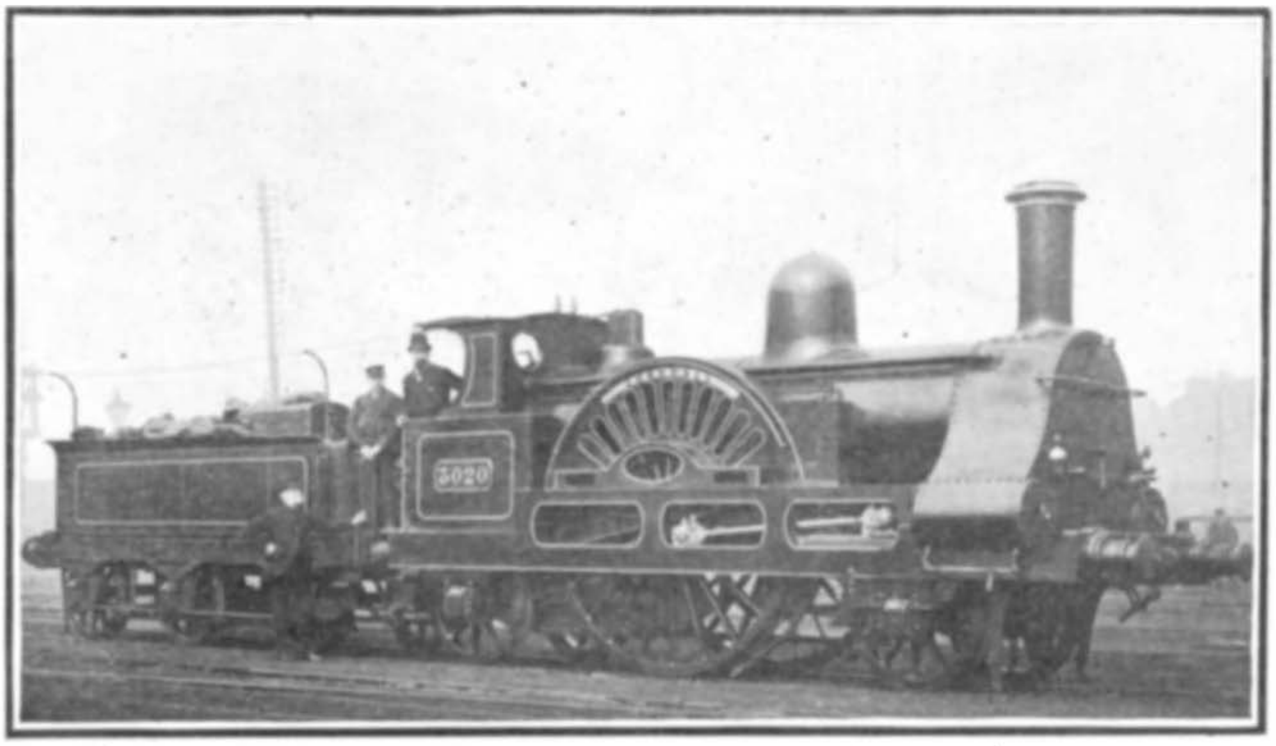


Fig. 2.—Express Engine "Cornwall" as It Is Running To-day. Largest Driving Wheels in the World.

One of the most prominent engineers to grapple with the low-boiler problem was Francis Trevithick, a son of the renowned "father of the locomotive." He was chief mechanical superintendent of the northern division of the London and North-Western Railway, England, and in order to compete with the broad-gage Great Western Railway, which had some fast engines with 8-foot driving wheels, he determined to produce a standard-gage engine, which should eclipse all others for size of wheels and speed. He conceived the idea of placing the boiler below the driving axle, and his designs were embodied in the remarkable engine shown in Fig. 1, in which the outline of the boiler is indicated by dotted lines. This locomotive was built at the Crewe Works, England, in November, 1847, and was named "Cornwall," after Trevithick's native county.

The bottom of the boiler at the front end was cut away to make room for the axles of the leading wheels, so that the tubes in the lower rows were shorter than the others. This was not a good design, and its defects were soon made manifest under the severe strains inseparable from high speeds. The axle of the trailing wheels passed through the fire-box by way of a circular water bridge, and upright water tubes connected this bridge with the crown sheet to insure good circulation.

Following are some of the leading dimensions: Cylinders, 17½ inches diameter by 24 inches stroke; diameter of driving wheels, 8 feet 6 inches; weight in working order, 27 long tons. In Sekon's "Evolution of the Steam Locomotive," the heating surface is given as 1,046 square feet. The valve motion was outside the driving wheels, and one eccentric actuated a vibrating arm which worked the feed pump.

A speed of 117 miles an hour has been claimed for this engine when going down the Madeley Bank on a trial trip, but this statement must be accepted with reserve, as the special instruments we now have for ascertaining railway speeds were unknown in those days, and on the occasion in question the timing was probably done with an ordinary stop watch. However this may have been, the engine certainly attained a speed of fully 79 miles an hour when running under favorable circumstances, and this was very good for the year 1847—exceeding, as it did, the highest speeds made by Gooch's best engines on the broad gage.

In the year 1851, the "Cornwall" was shown at the London International Exhibition, which, as is generally known, was the first "World's Fair" ever held. As originally built, the engine had two steam domes, but when placed in the exhibition the domes had apparently been removed and at least one safety-valve column substituted on the fire-box, as shown in Fig. 1, which is a copy of the engraving published in the Exhibition catalogue. A medal was awarded for this engine by the Exhibition judges.

This engine hauled express trains for about nine years, when in November, 1858, it was rebuilt as a six-wheel engine, with a standard boiler above the driving axle. Since then it has been twice overhauled, and fitted with modern improvements. For years it ran the express trains between Manchester and Liverpool, covering the distance in 40 minutes, and, with a load in proportion to its power, it is still capable of the highest speeds. Fig. 2 shows the engine as it is running to-day, but it has lately been put to working the daily local passenger trains between Chester and Whitchurch. Its mileage record from November, 1858, to November 30, 1904, is 921,220 miles. It is one of the oldest locomotives now running, and has the largest driving wheels in the world. In this latter connection it may be remarked that with the boiler pressure of 140 pounds to the square inch, the tractive effort of the "Cornwall"

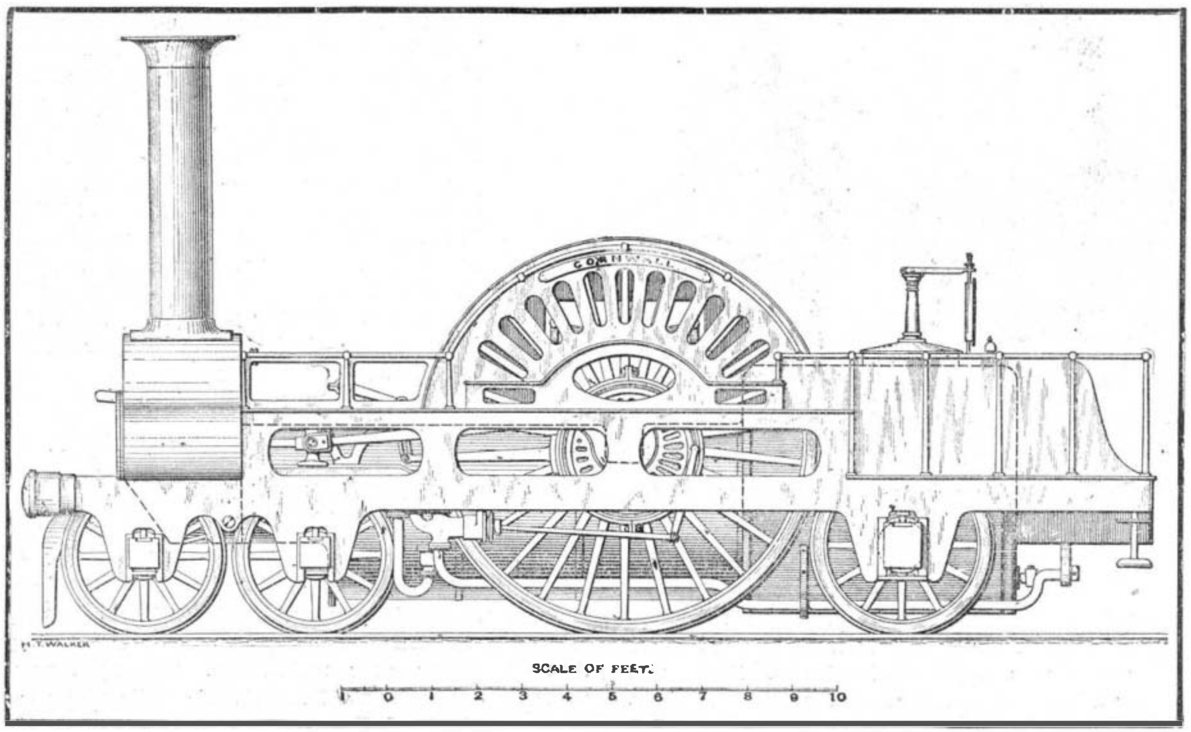


Fig. 1.—London and North-Western Railway Express Engine "Cornwall," 1847.

AN OLD HIGH-SPEED LOCOMOTIVE.

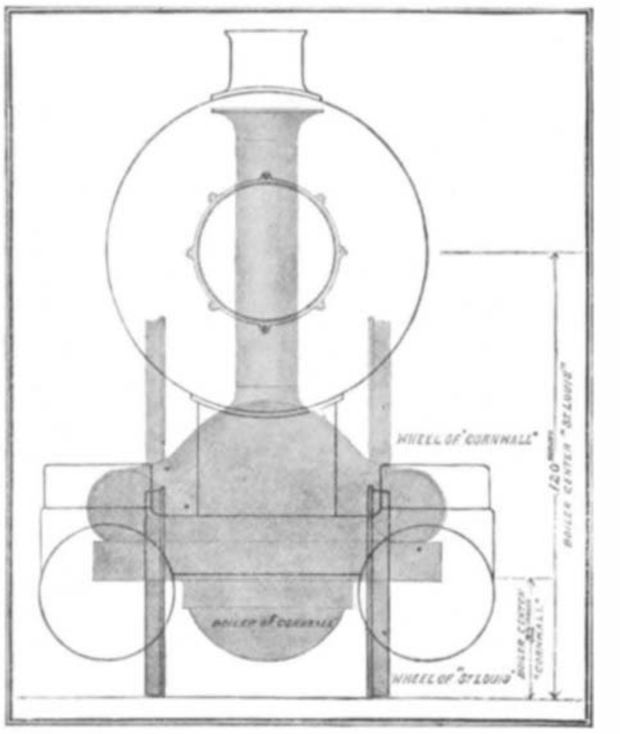


Fig. 3.—Comparative Diagram of the "Cornwall," 1847, and the "St. Louis," 1904.

is about 8,575 pounds, which, of course, is low from a modern standpoint, as the big Mallet compound engine "St. Louis" of the Baltimore & Ohio Railroad, which was exhibited at the recent St. Louis Exposition, has a drawbar pull of 80,000 pounds. Furthermore, it is interesting to note that the center line of the boiler of the "Cornwall" in its original form was only 2 feet 8 inches from the rails, while that of the "St. Louis" is no less than 10 feet from the rails—a sweeping refutation of the old low-boiler theory. Indeed, as railway speeds have advanced, locomotive boilers have been raised, and it has been found that engines with high boilers are steadier and easier on the track than those with a low center of gravity. This center of gravity is far lower than was at one time supposed, for in recent years the matter has been practically studied, and by experiments carried on at the Rogers Locomotive Works in 1899 with a 218,000-pound consolidation engine having a boiler center 9 feet 2 inches above the rails, the center of gravity was found to be just in front of the fire-box and only 4 feet 2½ inches from the rails. A prominent engineer at that time calculated that it would need a speed of 132 miles an hour round a 30-chain curve with no superelevation of the outer rail to cause this engine to capsize. We have thus gained the knowledge that in spite of a high boiler barrel (which is relatively light) the weight of the cylinders, frames, connecting rods, etc., keeps the center of gravity low.

Fig. 3 is a graphic illustration of the enormous strides which have been made in locomotive dimensions, the difference of boiler heights of the "Cornwall" and the "St. Louis" being strikingly evident. It will also be noticed that the diameter of the cylinders of the latter engine nearly approaches that of the boiler of Trevithick's engine.

With regard to driving wheels, it may be said that the movement in favor of small wheels (about 5 feet diameter) began in this country, our average speeds being lower and our loads heavier than in England, although our designers have produced some fast engines with comparatively small driving wheels, attaining this result by means of large steam ports, giving a quick valve opening for both steam and exhaust.

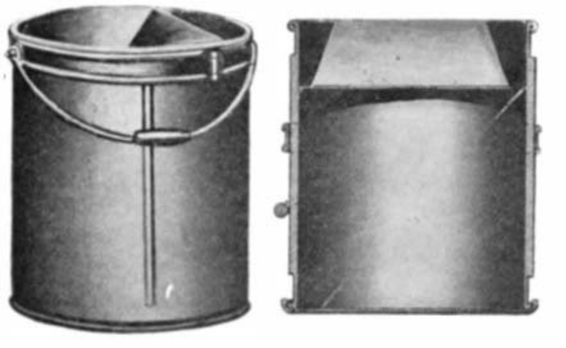
As time went on, speeds were gradually raised but wheel diameters remained practically unchanged, resulting in a loss of efficiency not fully understood until recent years. This branch of locomotive engineering has been practically studied at Purdue University, and Prof. Goss, dean of the schools of engineering at that institution, has kindly given the writer some original information showing that for all locomotives there is a speed point for which the output of power will become maximum, since in the scale of speed, this occurs when the boiler capacity is reached. When the Purdue engine "Schenectady" (No. 1), which has cylinders 17 inches diameter by 24 inches stroke and 56-inch driving wheels, was tested to ascertain its maximum power speed, it was found that the economy attending the cylinder action was highest at a speed of 35 miles an hour, and as the number of revolutions was increased above this speed, the economy of the engine proportionately diminished, the loss of mean effective pressure from the high piston velocity being greater than the gain in speed. This point at which the power no longer increases with the speed is known as the "critical speed" of a locomotive and will of course vary in different engines. In the Purdue engine it is, as we have seen, 35 miles an hour, which is a comparatively low speed—at least for passenger engines.

Since the piston velocity is governed by the diameter of the driving wheels, an engine of given cylinder volume will use more steam per mile with small drivers than with large ones. We can therefore understand how a fast engine may be crippled by having the driving wheels too small for the boiler. This has often occurred in practice, for many of our engines of a few years ago were of the same dimensions as the Purdue locomotive, so that while the drivers of the "Cornwall" are too large for paying train loads, the reaction in favor of small wheels swung to the opposite extreme, until the Purdue experiments led to the advancement of an argument in favor of larger drivers for high speeds—an argument which has found satisfactory response in the practice of recent years, for many of our express engines have now 7-foot driving wheels. In conclusion the writer takes pleasure in thanking Mr. George Whale, chief mechanical engineer of the London and North-Western Railway, for his courtesy in furnishing many interesting particulars of the engine forming the subject of this notice.

The St. Louis Republic says the inventor of to-day is no longer invested with the pathos of unrequited patience, but is the man of all others who leaps to eminence and fortune.

A NOVEL MILK PAIL.

The milk pail which is pictured in the accompanying engraving is provided, in addition to the receptacle for milk, with a compartment for carrying a sponge and a chamber for water to be used in washing the cow's udder before milking so that the milk will be kept clean. According to the arrangement the pail is made reversible, being in one position adapted to carry water and in the reverse position to receive milk. In our illustration the pail is shown with the milk receptacle inverted and the water and sponge compartments at the top. A transverse wall separates these compartments from the milk receptacle, and an inclined wall separates the water compartment from the sponge-holder. This inclined wall, it will be observed, forms a contracted mouth for the sponge compartment, so that the sponge will be retained while the pail is carried in reverse position. A ring or band encircles the body of the pail and is prevented from slipping off by the crimped edges of the pail. To this band the bail is hinged. On the body of the pail two ribs are formed which prevent the band from dropping down to the lower end. However, two offsets are formed on the band so that when the pail is reversed they may be brought into register with the ribs and the band may be raised, bringing the bail in position for use. Our section view is taken through the ribs and shows the bail being raised after the pail has been reversed. When raised to the top, the band is given a half turn to prevent it from slipping down again. A suitable cover closes the mouth of the milk receptacle and prevents entrance of dirt when the pail is set on the ground in an inverted position. It also serves as a protection when carrying the milk. Mr. Fred W. Lechner, of Winona, Ill. (R.F.D. No. 11) is the inventor of this novel milk pail.

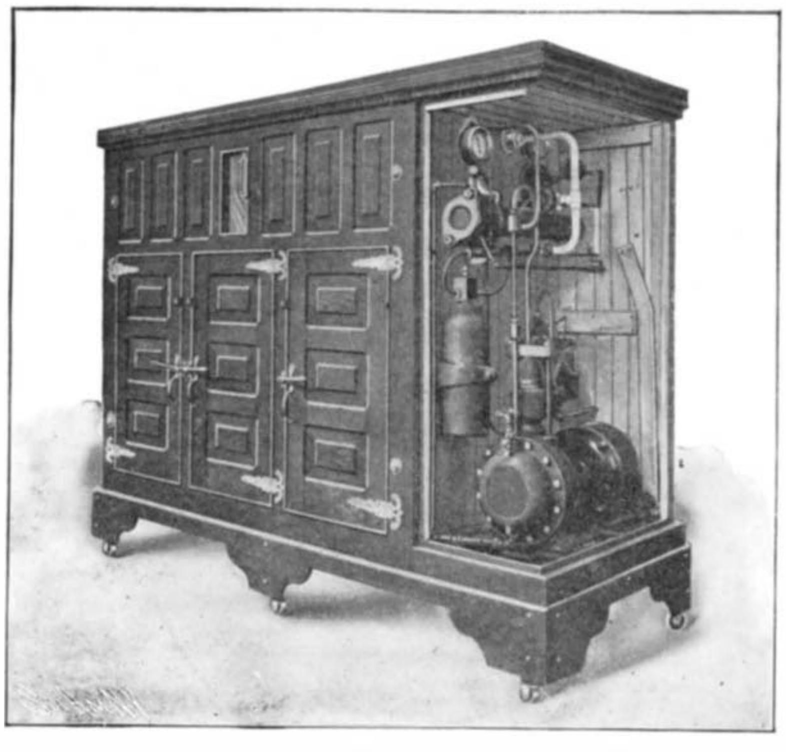


A NOVEL MILK PAIL.

AN ICELESS ELECTRIC REFRIGERATOR ON A SMALL SCALE.

BY GEORGE J. JONES.

Ever since the perfection of the cold storage plant money and brains have been expended in producing an iceless refrigerator. It was generally conceded that there was a demand on the part of dairymen, soda fountain proprietors, saloon keepers, butchers, and grocerymen for something that would make them independent of the iceman, and this seems at last to have been accomplished. Besides being a great convenience, the new refrigerator has a number of other recommendations, notably its cleanliness. Because of the great amount of moisture in the interior of the refrigerator, and because of the material usually stored within, the walls tend to become foul unless cleaned with scrupulous care at frequent intervals. This condition is brought about all the more quickly where the ice is not pure. Moreover, the charging of the ice receptacle every day is a nuisance. All this is done away with by means of electric refrigeration.



ARTIFICIAL REFRIGERATION ON A SMALL SCALE.

The electric refrigerator is a self-contained and automatic cold storage plant in a small way. It almost takes care of itself. The switch controlling the electric current is the only part that must be manipulated.

A refrigerator of this kind has been in operation for some time as an experiment in a Philadelphia grocery store. When the store is opened in the morning, the current is turned on and remains so during the day. Although the box is being constantly opened and closed, the temperature is maintained at 34 degrees. About the best temperature obtainable by the ordinary method of icing is 40 to 42 degrees. When the store is closed for the night the current is shut off, and the temperature remains almost constant all night. The difference shown by the mercury between the closing and opening hours is never more than one degree. During all this time no operating expenses whatever have been incurred.

The largest soda fountain in Philadelphia has been in operation for several months, and the materials drawn therefrom have been uniformly several degrees colder than could be secured with the use of shaved ice, and yet no ice has been used in it. A motor of one-half horse-power in the cellar operates a refrigerating plant, which not only keeps the fountain at a frigid temperature, but also does some additional work of a similar character in the cellar.

The iceless refrigerator is much the same in appearance as any large refrigerator. In a compartment at one end a motor and all the necessary compressors and other paraphernalia are contained. The place usually occupied by the ice is given over to a tank containing brine, which is the means of cooling the interior of the refrigerator. The principle is identical with that of the large refrigerating establishments, but this is the first time that the system has been reduced to an automatic basis. No expert knowledge of either electricity or refrigeration is required in order to operate one of these outfits. The types now being manufactured are of the sizes which are likely to be required by storekeepers who would ordinarily make use of at least two hundred pounds of ice daily. The next step will be the manufacture of one which will be available for the larger householder, and will be operated by a motor of one-eighth horse-power.

Another notable feature of one of these equipments is that where it is desired to have ice for use on the table, these machines will make it while performing their ordinary functions. One of the refrigerators has facilities for making two ten-pound pieces of ice per day, and another with a little different arrangement will make a number of small cubes.

A 10,000 Horse-Power Parsons Turbine.

Two steam turbine sets of 10,000 horse-power each, which are being installed at the Rhenanian Westphalian electricity works, are the largest turbine sets, and in fact the largest stationary engines of all Europe. Each of these gigantic engines comprises a turbine running at 1,000 r. p. m., which is direct-connected to a rotary current generator of 5,000 kilowatts, 5,000 volts, and 50 periods per second, as well as to a direct-current generator of 1,500 kilowatts and 600 volts, and to a central condensing plant. The whole set is 20 meters in length, and weighs 190 tons, of which 9.4 meters and 107 tons correspond to the turbine. The maximum height of the turbine above the floor is 2.6 meters, and the maximum breadth likewise 2.6 meters. The turbine is of the single-cylinder type, and has only two bearings, one of which serves at the same time as a bearing to the alternator. The governor is made to compensate to 1 per cent for any oscillations in the angular speed, with variations in the load as high as 20 per cent, while the maximum variation in the number of revolutions between running at no load and at full load is not to exceed 5 per cent. Another unit of the same size is shortly to be installed at the power station in a Westphalian mining company.

The Heaviest Rails.

The rails on the Belt Line Road around Philadelphia are the heaviest rails used on any railroad in the world. They weigh 142 pounds to the yard, and are 17 pounds heavier than any rails ever used before. They are ballasted in concrete, and 9-inch girders were used to bind them. All the curves and spurs were made of the same heavy rails, and the tracks are considered superior to any railroad section ever undertaken. The rails were made especially for the Pennsylvania Railroad by the Pennsylvania Steel Company. An officer of the railroad company states that this section of roadbed will last for twenty-five years without repairs.—International Railway Journal.